Automotive SPICE®

Process Reference Model

Process Assessment Model

Version 4.0

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Document history

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2.1	2005-06-24	AutoSIG / SUG	Editorial review comments implemented Updated to reflect changes in FDIS 15504-5
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2.3	2007-05-05	AutoSIG / SUG	Revision following CCB: FORMAL RELEASE
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2.5	2010-05-10	AutoSIG / SUG	Revision following CCB: FORMAL RELEASE
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4.0	**2023-10-20**	**VDA QMC WG13**	**Complete revision of PAM**

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1. Introduction

1.1. Scope

Process assessment is a disciplined evaluation of an organizational unit's processes against a process assessment model.

The Automotive SPICE process assessment model (PAM) is intended for use when performing conformant assessments of the process capability on the development of embedded automotive systems. It was developed in accordance with the requirements of ISO/IEC 33004:2015.

Automotive SPICE has its own process reference model (PRM), which was developed based on the Automotive SPICE process reference model 4.5. It was further developed and tailored considering the specific needs of the automotive industry. If processes beyond the scope of Automotive SPICE are needed, appropriate processes from other process reference models such as ISO/IEC 12207 or ISO/IEC/IEEE 15288 may be added based on the business needs of the organization.

The PRM is incorporated in this document and is used in conjunction with the Automotive SPICE process assessment model when performing an assessment.

This Automotive SPICE process assessment model contains a set of indicators to be considered when interpreting the intent of the Automotive SPICE process reference model. These indicators may also be used when implementing a process improvement program.

1.2. Terminology

Automotive SPICE follows the following precedence for use of terminology:

- ISO/IEC 33001 for assessment related terminology
- ISO/IEC/IEEE 24765, ISO/SAE 21434 and ISO/IEC/IEEE 29119 terminology (as contained in Annex C)
- Terms introduced by Automotive SPICE (as contained in Annex C)
- PMBOK® Guide – Fourth Edition
- PAS 1883:2020

Term	Origin	Description
Activity	Automotive SPICE V4.0	Execution of a task by a stakeholder or an involved party.
Application parameter	Automotive SPICE V4.0	An application parameter is a software variable containing data that can be changed at the system or software levels; they influence the system's or software behavior and properties. The notion of application parameter is expressed in two ways: • The specification (including variable names, the domain value range, technical data types, default values, physical unit (if applicable), the corresponding memory maps, respectively). • The actual quantitative data value it receives by means of data application. Application parameters are not requirements. They are a technical implementation solution for configurability-oriented requirements.

Approval	Automotive SPICE V4.0	Written statement that a deliverable is fit for its intended use, and compliant with defined criteria.
Baseline	Automotive SPICE V4.0	A defined and coherent set of read-only information, serving as an input information the for affected parties.
Deliverable	PMBOK® Guide – Fourth Edition	Any unique and verifiable product, result, or capability to perform a service that must be produced to complete a process, phase, or project. Often used more narrowly in reference to an external deliverable, which is a deliverable that is subject to approval by the project sponsor or customer.
Functional requirement	ISO/IEC/IEEE 24765	A statement that identifies what a product or process must accomplish to produce required behavior and/or results.
Hardware	intacs® working group HW PAM	Assembled and interconnected electrical or electronic hardware components or parts which perform analog or digital functions or operations.
Hardware component	intacs® working group HW PAM	Logical (e.g., functional block) or physical group of hardware parts realizing a functionality, which • cannot be realized by any of its hardware parts alone, e.g., voltage monitoring, power supply. • may be organized hierarchically, i.e., a hardware component can contain lower-level hardware components. *NOTE: Depending on the application, e.g., the populated PCB, a system-on-chip, a microcontroller, or an SBC can be considered a HW component.*
Hardware element	intacs® working group HW PAM	Generic term; can represent a hardware component, a hardware part, a hardware interface, or the hardware.
Hardware part	Automotive SPICE V4.0	Fundamental HW element the purpose and functionality of which cannot be further subdivided or separated. *NOTE: Examples are transistors, resistors, diodes, non-populated PCB* *NOTE: Depending on the application, e.g., a system-on-chip, a microcontroller or an SBC can be considered a HW part.* *NOTE: the term 'unit' is considered to apply to the software domain only. The term 'hardware part' can be viewed as the hardware counterpart of 'software unit'.*
Hyperparameter	Automotive SPICE V4.0	In machine learning, a hyperparameter is a parameter whose value is used to control the training of the ML model. Its value must be set between training iterations. Examples: learning rate, loss function, model depth, regularization constants.
Information need	Automotive SPICE V4.0	The need for characterizing process or product related effectiveness and efficiency (used by MAN.6 and PA 4.1).
Machine Learning (ML)	Automotive SPICE V4.0	In Automotive SPICE Machine Learning (ML) describes the ability of software to learn from specific training data and to apply this knowledge to other similar tasks.
Measure	Automotive SPICE V4.0	An activity to achieve a certain intent.
Measurement	Oxford Dictionary	"The activity to find the size, quantity or degree of something".

Metric	Automotive SPICE V4.0	A quantitative or qualitative measurable indicator that matches defined information needs.
Operational Design Domain	PAS 1883:2020	Operational Design Domain (ODD) is operating conditions under which a given overall system or feature thereof is specifically designed to function. This includes, but is not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics.
Project	ISO/IEC/IEEE 24765	Endeavor with defined start and finish dates undertaken to create a product or service in accordance with specified resources and requirements.
Release	Automotive SPICE V4.0	A physical product delivered to a customer, including a defined set of functionalities and properties.
Regression verification	Automotive SPICE V4.0	Selective re-verification of elements to verify that modifications have not caused unintended effects.
Risk	ISO/IEC/IEEE 24765	The combination of the probability of occurrence and the consequences of a given future undesirable event.
Software component	Automotive SPICE V4.0	Software component in design and implementation-oriented processes: The software architecture decomposes the software into software components across appropriate hierarchical levels down to the lowest-level software components in a conceptual model. Software component in verification-oriented processes: The implementation of a SW component under verification is represented e.g., as source code, object files, library file, executable, or executable model.
Software element	Automotive SPICE V4.0	Refers to software component or software unit
Software unit	Automotive SPICE V4.0	Software unit in design and implementation-oriented processes: As a result of the decomposition of a software component, the software is decomposed into software units which are a representation of a software element, which is decided not to be further subdivided and that is a part of a software component at the lowest level, in a conceptual model. Software unit in verification-oriented processes: An implemented SW unit under verification is represented e.g., as source code files, or an object file.
Stakeholder requirements	Automotive SPICE V4.0	Any type of requirement for the stakeholders in the given context, e.g., customer requirement, supplier internal requirements (product-specific, platform etc.), legal requirements, regulatory requirements, statutory requirements, industry sector requirements, international standards, codes of practice etc. …

System Element	Automotive SPICE V4.0	System elements can be: • Logical and structural objects at the architectural and design level. System elements can be further decomposed into more fine-grained system elements of the architecture or design across appropriate hierarchical levels. • Physical representations of these objects, or a combination, e.g., peripherals, sensors, actuators, mechanical parts, software executables.
Task	Automotive SPICE V4.0	A definition, but not the execution, of a coherent and set of atomic actions.
Validation measure	Automotive SPICE V4.0	Validation measure can be: • Operational use case testing under real-life conditions • Highly accelerated life testing (HALT) • Simulations under real-life conditions • End user trials • Panel or blind tests • Expert panels
Verification	Automotive SPICE V4.0	Verification is confirmation through the provision of objective evidence that an element fulfils the specified requirements.
Verification measure	Automotive SPICE V4.0	Verification measure can be: • Test cases • Measurements • Calculations • Simulations • Reviews • Analyses Note, that in particular domains certain verification measures may not be applicable, e.g., software units generally cannot be verified by means of calculations or analyses.

Table 1 — Terminology

1.3. Abbreviations

BP	**B**ase **P**ractice
CAN	**C**ontroller **A**rea **N**etwork
CASE	**C**omputer-**A**ided **S**oftware **E**ngineering,
CCB	**C**hange **C**ontrol **B**oard
CPU	**C**entral **P**rocessing **U**nit
ECU	**E**lectronic **C**ontrol **U**nit
EEPROM	**E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory
EOL	**E**nd-**o**f-**L**ine
FMEA	**F**ailure **M**ode and **E**ffect **A**nalysis
FTA	**F**ault **T**ree **A**nalysis
GP	**G**eneric **P**ractice
GR	**G**eneric **R**esource
IEC	**I**nternational **E**lectrotechnical **C**ommission
IEEE	**I**nstitute of **E**lectrical and **E**lectronics **E**ngineers
I/O	**I**nput / **O**utput
ISO	**I**nternational **O**rganization for **S**tandardization
LIN	**L**ocal **I**nterconnect **N**etwork
MISRA	**M**otor **I**ndustry **S**oftware **R**eliability **A**ssociation
MOST	**M**edia **O**riented **S**ystems **T**ransport
ODD	**O**perational **D**esign **D**omain
PA	**P**rocess **A**ttribute
PAM	**P**rocess **A**ssessment **M**odel
PRM	**P**rocess **R**eference **M**odel
PWM	**P**ulse **W**idth **M**odulation
RAM	**R**andom **A**ccess **M**emory
ROM	**R**ead **O**nly **M**emory
SPICE	**S**ystems **P**rocess **I**mprovement and **C**apability d**E**termination
SUG	**S**pice **U**ser **G**roup
USB	**U**niversal **S**erial **B**us
WP	**W**ork **P**roduct
WPC	**W**ork **P**roduct **C**haracteristic

Table 2 — Abbreviation List

2. Statement of compliance

The Automotive SPICE process reference model and process assessment model are conformant with the ISO/IEC 33004:2015 and can be used as the basis for conducting an assessment of process capability.

An ISO/IEC 33003:2015 compliant Measurement Framework is defined in section 5.

A statement of compliance of the process assessment model and process reference model with the requirements of ISO/IEC 33004:2015 is provided in Annex A.

A statement of compliance of the measurement framework with the requirements of ISO/IEC 33003:2015 is provided in Annex A.

3. Process capability determination

The concept of process capability determination by using a process assessment model is based on a two-dimensional framework. The first dimension is provided by processes defined in a process reference model (process dimension). The second dimension consists of capability levels that are further subdivided into process attributes (capability dimension). The process attributes provide the measurable characteristics of process capability.

The process assessment model selects processes from a process reference model and supplements with indicators. These indicators support the collection of objective evidence which enable an assessor to assign ratings for processes according to the capability dimension.

The relationship is shown in Figure 1.

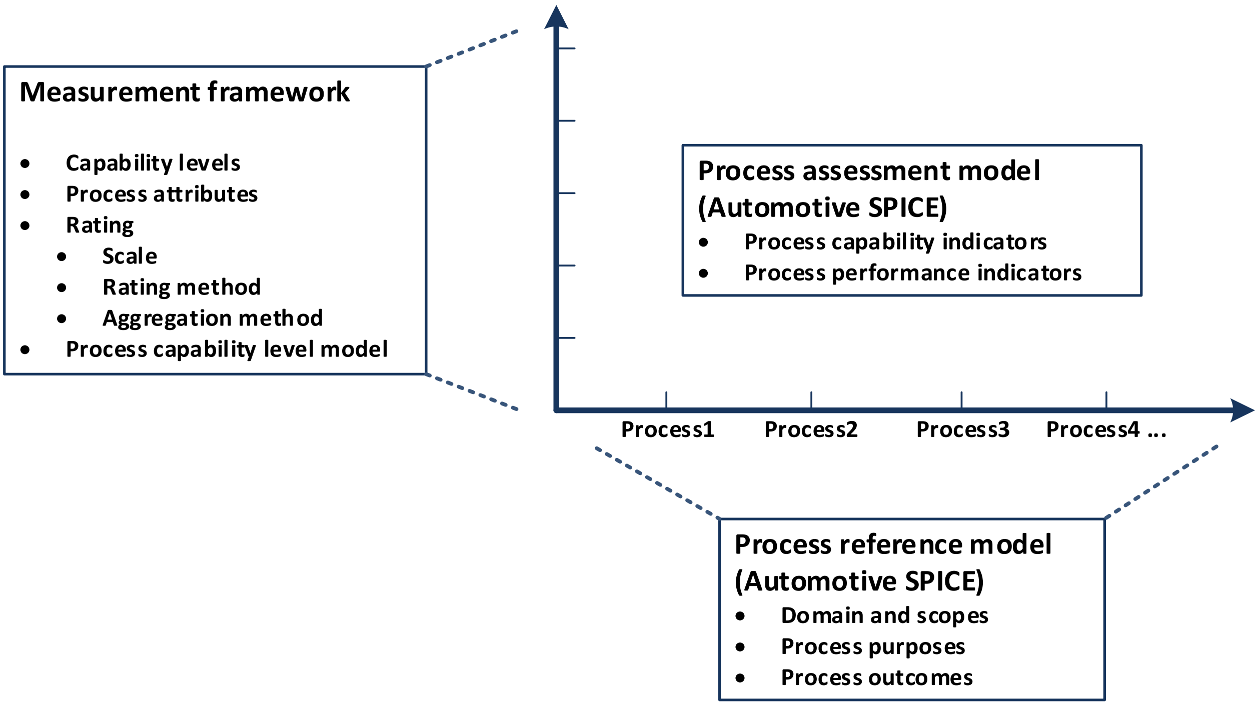

Figure 1 — Process assessment model relationship

3.1. Process reference model

Processes are collected into process groups according to the domain of activities they address.

These process groups are organized into 3 process categories: Primary life cycle processes, Organizational life cycle processes and Supporting life cycle processes.

For each process a purpose statement is formulated that contains the unique functional objectives of the process when performed in a particular environment. For each purpose statement a list of specific outcomes is associated, as a list of expected positive results of the process performance.

For the process dimension, the Automotive SPICE process reference model provides the set of processes shown in Figure 2.

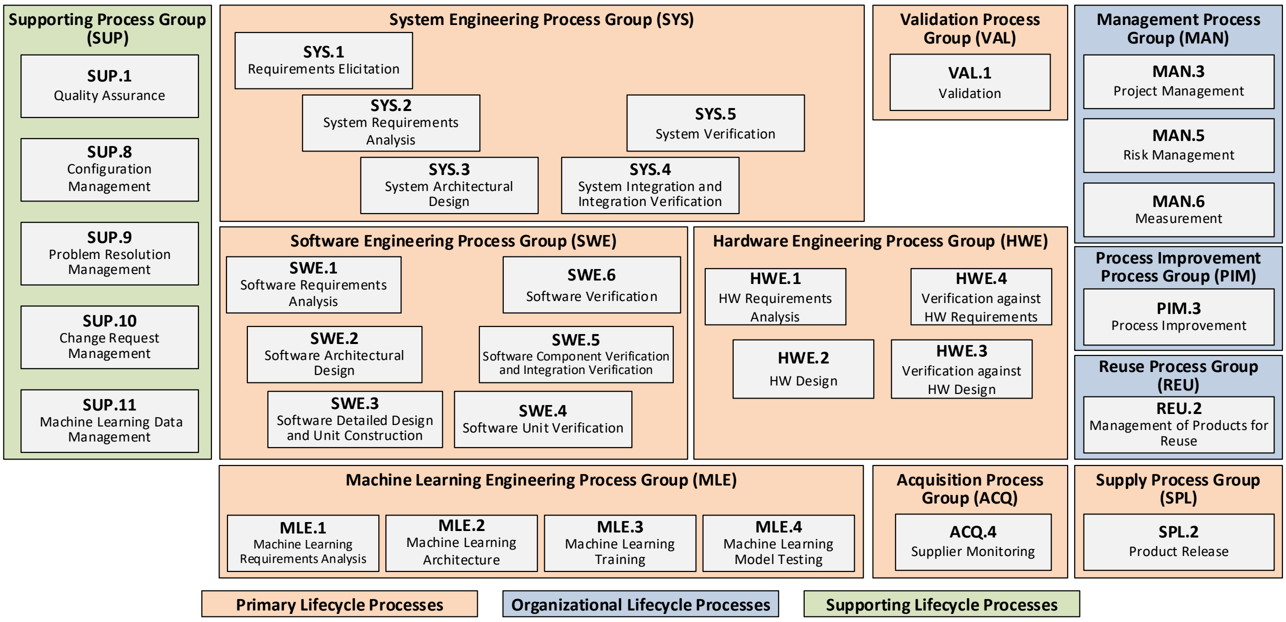

Figure 2 — Automotive SPICE process reference model - Overview

3.1.1. Primary life cycle processes category

The primary life cycle processes category consists of processes that may apply for an acquirer of products from a supplier or may apply for product development when responding to stakeholder needs and delivering products including the engineering processes needed for specification, design, implementation, integration and verification.

The primary life cycle processes category consists of the following groups:

- the Acquisition process group
- the Supply process group
- the System engineering process group
- the Validation process group
- the Software engineering process group
- the Machine learning engineering process group
- the Hardware engineering process group

The Acquisition process group (ACQ) consists of one process that is performed by the customer, or by the supplier when acting as a customer for its own suppliers, in order to acquire a product and/or service.

ACQ.4	Supplier Monitoring

Table 3 — Primary life cycle processes – ACQ process group

The Supply process group (SPL) consists of one process performed by the supplier in order to supply a product and/or a service.

SPL.2	Product Release

Table 4 — Primary life cycle processes – SPL process group

The System Engineering process group (SYS) consists of processes addressing the elicitation and management of customer and internal requirements, the definition of the system architecture and the integration and verification on the system level.

SYS.1	Requirements Elicitation
SYS.2	System Requirements Analysis
SYS.3	System Architectural Design
SYS.4	System Integration and Integration Verification
SYS.5	System Verification

Table 5 — Primary life cycle processes – SYS process group

The Validation process group (VAL) consists of one process that is performed to provide evidence that the product to be delivered satisfies the expectations for its intended use.

VAL.1	Validation

Table 6 — Primary life cycle processes – VAL process group

The Software Engineering process group (SWE) consists of processes addressing the management of software requirements derived from the system requirements, the development of the corresponding software architecture and design as well as the implementation, integration and verification of the software.

SWE.1	Software Requirements Analysis
SWE.2	Software Architectural Design
SWE.3	Software Detailed Design and Unit Construction
SWE.4	Software Unit Verification
SWE.5	Software Component Verification and Integration Verification
SWE.6	Software Verification

Table 7 — Primary life cycle processes – SWE process group

The Machine Learning Engineering process group (MLE) consists of processes addressing the management of ML requirements derived from the software requirements, the development of the corresponding ML architecture, the training of ML model, and testing of ML model against ML requirements.

MLE.1	Machine Learning Requirements Analysis
MLE.2	Machine Learning Architecture

MLE.3	Machine Learning Training
MLE.4	Machine Learning Model Testing

Table 8 — Primary life cycle processes – MLE process group

The Hardware Engineering process group (HWE) consists of processes addressing the management of hardware requirements derived from the system requirements, the development of the corresponding hardware architecture and design as well as the verification of the hardware.

HWE.1	Hardware Requirements Analysis
HWE.2	Hardware Design
HWE.3	Verification against Hardware Design
HWE.4	Verification against Hardware Requirements

Table 9 — Primary life cycle processes – HWE process group

3.1.2. Supporting life cycle processes category

The supporting life cycle processes category consists of processes that may be employed by any of the other processes at various points in the life cycle.

SUP.1	Quality Assurance
SUP.8	Configuration Management
SUP.9	Problem Resolution Management
SUP.10	Change Request Management
SUP.11	Machine Learning Data Management

Table 10 — Supporting life cycle processes - SUP process group

3.1.3. Organizational life cycle processes category

The organizational life cycle processes category consists of processes that develop process, product, and resource assets which, when used by projects in the organization, may help the organization achieve its business goals.

The organizational life cycle processes category consists of the following groups:

- the Management process group;
- the Process Improvement process group;
- the Reuse process group.

The Management process group (MAN) consists of processes that may be used by anyone who manages any type of project or process within the life cycle.

MAN.3	Project Management
MAN.5	Risk Management
MAN.6	Measurement

Table 11 — Organizational life cycle processes - MAN process group

The Process Improvement process group (PIM) covers one process that contains practices to improve the processes performed in the organizational unit.

PIM.3	Process Improvement

Table 12 — Organizational life cycle processes - PIM process group

The Reuse process group (REU) covers one process to systematically exploit reuse opportunities in organization's product portfolio.

REU.2	Management of Products for Reuse

Table 13 — Organizational life cycle processes - REU process group

3.2. Measurement framework

The measurement framework provides the necessary requirements and rules for the capability dimension. It defines a schema which enables an assessor to determine the Capability Level of a given process. These capability levels are defined as part of the measurement framework.

To enable the rating, the measurement framework provides process attributes defining a measurable property of process capability. Each process attribute is assigned to a specific capability level. The extent of achievement of a certain process attribute is represented by means of a rating based on a defined rating scale. The rules from which an assessor can derive a final capability level for a given process are represented by a process capability level model.

Automotive SPICE defines its own measurement framework.

> *Note: The Automotive SPICE measurement framework is an adaption of ISO/IEC 33020:2019. Text incorporated from ISO/IEC 33020 within this chapter is written in italic font and marked with a left side bar.*

3.2.1. Process capability levels and process attributes

The process capability levels, and associated process attributes are described in detail in chapter 5.

Process attributes are features of a process that can be evaluated on a scale of achievement, providing a measurement of the capability of the process. They are applicable to all processes.

A capability level is characterized by one or more process attributes whose implementation result in a significant improvement in the capability to perform a process. Each attribute addresses a specific aspect of the capability level. The levels constitute a rational way of progressing through improvement of the capability of any process.

There are six capability levels as listed in Table 14, incorporating nine process attributes:

Level 0: Incomplete process	*The process is not implemented or fails to achieve its process purpose.*
Level 1: Performed process	*The implemented process achieves its process purpose*
Level 2: Managed process	*The previously described performed process is now implemented in a managed fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained.*

Level 3: Established process	*The previously described managed process is now implemented using a defined process that is capable of achieving its process outcomes.*
Level 4: Predictable process	*The previously described established process now operates predictively within defined limits to achieve its process outcomes. Quantitative management needs are identified, measurement data are collected and analyzed to identify assignable causes of variation. Corrective action is taken to address assignable causes of variation.*
Level 5: Innovating process	*The previously described predictable process is now continually improved to respond to organizational change.*

Table 14 — Process capability levels

Within this process assessment model, the determination of capability is based upon the nine process attributes (PA) as listed in Table 15 — Process attributes.

Attribute ID	Process Attributes
Level 0: Incomplete process	
Level 1: Performed process	
PA 1.1	*Process performance process attribute*
Level 2: Managed process	
PA 2.1	*Performance management process attribute*
PA 2.2	*Work product management process attribute*
Level 3: Established process	
PA 3.1	*Process definition process attribute*
PA 3.2	*Process deployment process attribute*
Level 4: Predictable process	
PA 4.1	*Quantitative analysis process attribute*
PA 4.2	*Quantitative control process attribute*
Level 5: Innovating process	
PA 5.1	*Process innovation process attribute*
PA 5.2	*Process innovation implementation process attribute*

Table 15 — Process attributes

3.2.2. Process attribute rating

To support the rating of process attributes, the measurement framework provides a defined rating scale with an option for refinement, different rating methods and different aggregation methods depending on the class of the assessment (e.g., required for organizational maturity assessments).

3.2.2.1. Rating scale

> *Within this process measurement framework, a process attribute is a measureable property of process capability. A process attribute rating is a judgement of the degree of achievement of the process attribute for the assessed process.*

The rating scale is shown in Table 16 — Rating scale.

Note. The rating scale is identical to ISO/IEC 33020:2019

N	*Not achieved*	*There is little or no evidence of achievement of the defined process attribute in the assessed process.*
P	*Partially achieved*	*There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.*
L	*Largely achieved*	*There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.*
F	*Fully achieved*	*There is evidence of a complete and systematic approach to, and full achievement of, the defined process attribute in the assessed process. No significant weaknesses related to this process attribute exist in the assessed process.*

Table 16 — Rating scale

The ordinal scale defined above shall be understood in terms of percentage achievement of a process attribute. The corresponding percentages shall be:

N	*Not achieved*	*0 to ≤ 15% achievement*
P	*Partially achieved*	*> 15% to ≤ 50% achievement*
L	*Largely achieved*	*> 50% to ≤ 85% achievement*
F	*Fully achieved*	*> 85% to ≤ 100% achievement*

Table 17 — Rating scale percentage values

The ordinal scale may be further refined for the measures P and L as defined below.

P-	*Partially achieved:*	*There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Many aspects of achievement of the process attribute may be unpredictable.*
P+	*Partially achieved:*	*There is some evidence of an approach to, and some achievement of, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.*
L-	*Largely achieved:*	*There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Many weaknesses related to this process attribute may exist in the assessed process.*
L+	*Largely achieved:*	*There is evidence of a systematic approach to, and significant achievement of, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.*

Table 18 — Refinement of rating scale

The corresponding percentages shall be:

P-	*Partially achieved -*	*> 15% to ≤ 32.5% achievement*
P+	*Partially achieved +*	*> 32.5 to ≤ 50% achievement*
L-	*Largely achieved -*	*> 50% to ≤ 67.5% achievement*
L+	*Largely achieved +*	*> 67.5% to ≤ 85% achievement*

Table 19 — Refined rating scale percentage values

3.2.3. Rating and aggregation method

Rating and aggregation methods are taken from ISO/IEC 33020:2019, which provides the following definitions:

> *A process outcome is the observable result of successful achievement of the process purpose.*
>
> *A process attribute outcome is the observable result of achievement of a specified process attribute.*
>
> *Process outcomes and process attribute outcomes may be characterised as an intermediate step to providing a process attribute rating.*
>
> *When performing rating, the rating method employed shall be specified relevant to the class of assessment. The following rating methods are defined.*
>
> *The use of rating method may vary according to the class, scope and context of an assessment. The lead assessor shall decide which (if any) rating method to use. The selected rating method(s) shall be specified in the assessment input and referenced in the assessment report.*

ISO/IEC 33020:2019 provides the following 3 rating methods:

> ***Rating method R1***
>
> *The approach to process attribute rating shall satisfy the following conditions:*
>
> *a) Each process outcome of each process within the scope of the assessment shall be characterized for each process instance, based on validated data;*
>
> *b) Each process attribute outcome of each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data;*
>
> *c) Process outcome characterizations for all assessed process instances shall be aggregated to provide a process performance attribute achievement rating;*
>
> *d) Process attribute outcome characterizations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.*
>
> ***Rating method R2***
>
> *The approach to process attribute rating shall satisfy the following conditions:*
>
> *a) Each process attribute for each process within the scope of the assessment shall be characterized for each process instance, based on validated data;*
>
> *b) Process attribute characterizations for all assessed process instances shall be aggregated to provide a process attribute achievement rating.*
>
> ***Rating method R3***

> *Process attribute rating across assessed process instances shall be made without aggregation.*

In principle the three rating methods defined in ISO/IEC 33020:2019 depend on

a) whether the rating is made only on process attribute level (Rating method 3 and 2) or – with more level of detail – both on process attribute and process attribute outcome level (Rating method 1); and
b) the type of aggregation ratings across the assessed process instances for each process

If a rating is performed for both process attributes and process attribute outcomes (Rating method 1), the result will be a process performance attribute outcome rating on level 1 and a process attribute achievement rating on higher levels.

Depending on the class, scope and context of the assessment an aggregation within one process (one-dimensional, vertical aggregation), across multiple process instances (one-dimensional, horizontal aggregation) or both (two-dimensional, matrix aggregation) is performed.

ISO/IEC 33020:2019 provides the following examples:

> *When performing an assessment, ratings may be summarized across one or two dimensions.*
>
> *For example, when rating a*
>
> - *process attribute for a given process, one may aggregate ratings of the associated process (attribute) outcomes – such an aggregation will be performed as a vertical aggregation (one dimension).*
> - *process (attribute) outcome for a given process attribute across multiple process instances, one may aggregate the ratings of the associated process instances for the given process (attribute) outcome such an aggregation will be performed as a horizontal aggregation (one dimension)*
> - *process attribute for a given process, one may aggregate the ratings of all the process (attribute) outcomes for all the processes instances – such an aggregation will be performed as a matrix aggregation across the full scope of ratings (two dimensions)*

The standard defines different methods for aggregation. Further information can be taken from ISO/IEC 33020:2019.

3.2.4. Process capability level model

The process capability level achieved by a process shall be derived from the process attribute ratings for that process according to the process capability level model defined in Table 20 — Capability levels.

The process capability level model defines the rules how the achievement of each level depends on the rating of the process attributes for the assessed and all lower levels.

As a general rule the achievement of a given level requires a largely or fully achievement of the corresponding process attributes and a full achievement of any lower lying process attribute.

Scale	Process attribute	Rating
Level 1	PA 1.1: Process performance process attribute	Largely or fully
Level 2	PA 1.1: Process performance process attribute PA 2.1: Process performance management process attribute PA 2.2: Work product management process attribute	Fully Largely or fully Largely or fully
Level 3	PA 1.1: Process performance process attribute PA 2.1: Process performance management process attribute PA 2.2: Work product management process attribute PA 3.1: Process definition process attribute PA 3.2: Process deployment process attribute	Fully Fully Fully Largely or fully Largely or fully
Level 4	PA 1.1: Process performance process attribute PA 2.1: Process performance management process attribute PA 2.2: Work product management process attribute PA 3.1: Process definition process attribute PA 3.2: Process deployment process attribute PA 4.1: Quantitative analysis process attribute PA 4.2: Quantitative control process attribute	Fully Fully Fully Fully Fully Largely or fully Largely or fully
Level 5	PA 1.1: Process performance process attribute PA 2.1: Process performance management process attribute PA 2.2: Work product management process attribute PA 3.1: Process definition process attribute PA 3.2: Process deployment process attribute PA 4.1: Quantitative analysis process attribute PA 4.2: Quantitative control process attribute PA 5.1: Process innovation process attribute PA 5.2: Process innovation implementation process attribute	Fully Fully Fully Fully Fully Fully Fully Largely or fully Largely or fully

Table 20 — Capability levels and corresponding process attribute ratings

3.3. Process assessment model

The process assessment model offers indicators in order to identify whether the process outcomes and the process attribute outcomes (achievements) are present or absent in the instantiated processes of projects and organizational units. These indicators provide guidance for assessors in accumulating the necessary objective evidence to support judgments of capability. They are not intended to be regarded as a mandatory set of checklists to be followed.

3.3.1. Assessment indicators

According to ISO/IEC 33004, a process assessment model needs to define a set of assessment indicators:

> ***Assessment Indicators***
>
> *A process assessment model shall be based on a set of assessment indicators that:*
>
> *a) explicitly address the purpose and process outcomes, as defined in the selected process reference model, of each of the processes within the scope of the process assessment model;*
>
> *b) demonstrate the achievement of the process attributes within the scope of the process assessment model;*
>
> *c) demonstrate the achievement (where relevant) of the process quality levels within the scope of the process assessment model.*
>
> *The assessment indicators generally fall into three types:*
>
> *a) **practices** that support achievement of either the process purpose or the specific process attribute.*
>
> *b) **information items** and their characteristics that demonstrate the respective achievements.*
>
> *c) resources and infrastructure that support the respective achievements.*
>
> *[ISO/IEC 33004:2015, 6.3.1]*

In this assessment model, only practices and information items are used.

Practices are representing activity-oriented indicators, where information items are representing result-oriented indicators. Both practices and information items are used for judging objective evidence to be collected and accumulated in the performance of an assessment.

As a first type of assessment indicator, practices are provided, which can be divided into two types:

1. **Base practices (BP), applying to capability level 1**

   They provide an indication of the extent of achievement of the process outcomes. Base practices relate to one or more process outcomes, thus being always process-specific and not generic.

2. **Generic practices (GP), applying to capability levels 1 to 5**

   They provide an indication of the extent of process attribute achievement. Generic practices relate to one or more process attribute achievements, thus applying to any process.

As a second type of assessment indicators, **information items (II)** including their **characteristics (IIC)** are provided in Annex B.

These are meant to offer a good practice and state-of-the-art knowledge guide for the assessor. Therefore, information items including their characteristics are supposed to be a quickly accessible information source during an assessment.

Information item characteristics shall not be interpreted as a required structure of a corresponding work products, which is defined by the project and organization, respectively.

Please refer to chapter 3.3.2 for understanding the difference between information items and work products.

ISO 33004:2015 requires the mapping of assessment indicators to process attributes as shown in figure 3.

The capability of a process on level 1 is only characterized by the measure of the extent to which the process outcomes are achieved. According to ISO 33003:2015, a measurement framework requires each level to reveal a process attribute. Therefore, the only process performance attribute for capability Level 1 (PA.1.1) has a single generic practice (GP 1.1.1) pointing as an editorial reference to the respective process performance indicators (see figure 3 and chapter 4).

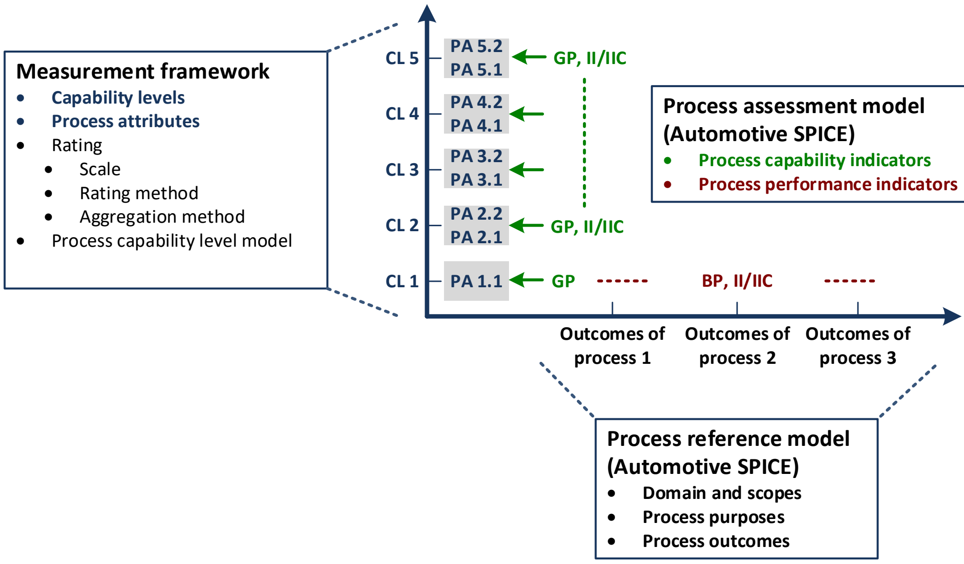

Figure 3 — Relationship between assessment indicators and process capability

The detailed mapping of base practices / indicators and generic practices / indicators to process outcomes and achievements, is provided in corresponding tables in chapter 4 and 5, respectively.

3.3.2. Understanding information Items and work products

In order to judge the presence or absence of process outcomes and process attribute achievements an assessment obtains objective evidence. All such evidence comes either from the examination of work products related to a specific output of the processes assessed, or from statements made by the performers and managers of the processes. Sources for such evidence is either repository content of the assessed processes, or testimony provided by the performers and managers of the assessed processes.

As described in chapter 3.3.1, this process assessment model provides information items serving as indicators to guide the assessor when judging a process attribute achievement.

3.3.2.1. Information items versus work products

ISO/IEC 33001 provides the following definition of the term “information item”:

> ***information item***
>
> *separately identifiable body of information that is produced, stored, and delivered for human use*
>
> *Note 1 to entry: An information item can be produced in several versions during a system, software, or service life cycle. Syn: information product.*
>
> *[ISO/IEC 33001:2015, 3.1.4]*

Note: Human use includes the information stored, managed and processed by a tool.

One common definition of the term “work product” is:

> ***work product***
>
> *artifact resulting from the execution of a process*
>
> *[ISO/IEC/IEEE 24765:2017]*

Both terms are used in different context in an assessment:

- Information items are defining relevant pieces of information used by the assessors to judge the achievement of process attributes.
- Work products are produced by the organization assessed when performing, managing, establishing, analyzing and innovating processes.

Information items (together with their characteristics) are provided as guidance for “what to look for” when examining the work products available in the assessed organization. The extent of implementation of an information item (in line with its defined characteristics) in a related work product serves as objective evidence supporting the assessment of a particular process. A documented process and assessor judgment is needed to ensure that the process context (application domain, business purpose, development methodology, size of the organization, etc.) is considered when using this information.

Information items shall therefore not be mistaken for the work product generated by the assessed organization itself. There is no 1:1 relationship between an information item and the work product taken as sample evidence by the assessor when assessing the achievement of a process outcome and process attribute achievements. An output generated by a process may comprise multiple information item characteristics and multiple outputs may also contain the same information item characteristics.

Information item characteristics should be considered as indicators when considering whether, given the context, a work product is contributing to the intended purpose of the process. Context-sensitivity means that assessor judgment is needed to ensure that the actual context (application domain, business purpose, development methodology, size of the organization, etc.) is considered when using the information items.

3.3.2.2. Types of work products

A work product to be considered as evidence when rating a process attribute may not necessary be outputs from the processes assessed but can also be originated from other processes of the organization. Once such a work product is used in the performance of a process under assessment, it may be considered by the assessor as objective evidence.

In a lot of cases work products are comprising documentation aspects, such as specifications, reports, records, architectural designs, software code etc.

Examples of work products not comprising any documentation aspects are software binaries, raw data, or a physical electronic hardware.

3.3.3. Understanding the level of abstraction of a PAM

The term "process" can be understood at three levels of abstraction. Note that these levels of abstractions are not meant to define a strict black-or-white split, nor is it the aim to provide a scientific classification schema – the message here is to understand that, in practice, when it comes to the term "process" there are different abstraction levels, and that a PAM resides at the highest.

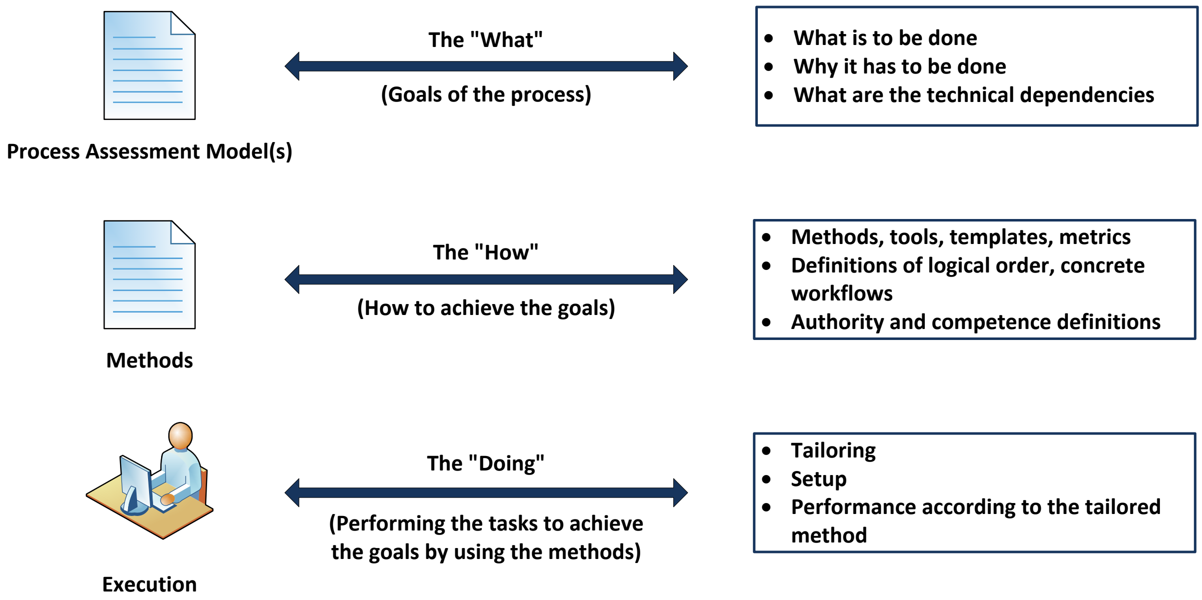

Figure 4 — Possible levels of abstraction for the term "process"

Capturing experience acquired during product development (i.e., at the DOING level) in order to share this experience with others means creating a HOW level. However, a HOW is always specific to a particular context such as a company, an organizational unit, or a product line. For example, the HOW of a project, organizational unit, or company A is potentially not applicable as is to a project, organizational unit, or company B. However, both might be expected to adhere the principles represented by PAM indicators for process outcomes and process attribute achievements. These indicators are at the WHAT level while deciding on solutions for concrete templates, proceedings, and tooling etc. is left to the HOW level.

3.3.4. Why a PRM and PAM are not a lifecycle model or development process blueprint

A lifecycle model defines phases and activities in a logical timely order, possibly including cycles or loops, and parallelization. For example, some standards such as ISO 26262 or ISO/SAE 21434 are centered around a lifecycle model (neither of these standards in fact represents a PRM according to ISO/IEC 33004). Companies, organizational units, or projects will interpret such general lifecycle models given in standards, and then detail it out into roles, organizational interactions and interfaces,

4.3. System engineering process group (SYS)

4.3.1. SYS.1 Requirements Elicitation

Process ID
SYS.1
Process name
Requirements Elicitation
Process purpose
The purpose is to gather, analyze, and track evolving stakeholder needs and requirements throughout the lifecycle of the product and/or service to establish a set of agreed requirements.
Process outcomes
1) Continuing communication with the stakeholder is established. 2) Stakeholder expectations are understood, and requirements are defined and agreed. 3) Stakeholder requirements changes arising from stakeholder needs are analyzed to enable associated risk assessment and impact management. 4) Determination of stakeholder requirements status is ensured for all affected parties.

Base Practices
SYS.1.BP1: Obtain stakeholder expectations and requests. Obtain and define stakeholder expectations and requests through direct solicitation of stakeholder input, and through review of stakeholder business proposals (where relevant) and other documents containing inputs to stakeholder requirements, and consideration of the target operating and hardware environment. *Note 1: Documenting the stakeholder, or the source of a stakeholder requirement, supports stakeholder requirements agreement and change analysis (see BP2 and BP3).*
SYS.1.BP2: Agree on requirements. Formalize the stakeholder's expectations and requests into requirements. Reach a common understanding of the set of stakeholder requirements among affected parties by obtaining an explicit agreement from all affected parties. *Note 2: Examples of affected parties are customers, suppliers, design partners, joint venture partners, or outsourcing parties.* *Note 3: The agreed stakeholder requirements may be based on feasibility studies and/or cost and schedule impact analysis.*
SYS.1.BP3: Analyze stakeholder requirements changes. Analyze all changes made to the stakeholder requirements against the agreed stakeholder requirements. Assess the impact and risks, and initiate appropriate change control and mitigation actions. *Note 4: Requirements changes may arise from different sources as for instance changing technology, stakeholder needs, or legal constraints.* *Note 5: Refer to SUP.10 Change Request Management, if required.*

SYS.1.BP4: Communicate requirements status. Ensure all affected parties can be aware of the status and disposition of their requirements including changes and can communicate necessary information and data.

SYS.1 Requirements Elicitation	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Output Information Items				
15-51 Analysis Results			X	
13-52 Communication Evidence	X	X		
17-00 Requirement		X		
17-54 Requirement Attribute		X	X	X
Base Practices				
BP1: Obtain stakeholder expectations and requests	X			
BP2: Agree on requirements		X		
BP3: Analyze stakeholder requirements changes			X	
BP4: Communicate requirements status	X			X

4.3.2. SYS.2 System Requirements Analysis

Process ID
SYS.2
Process name
System Requirements Analysis
Process purpose
The purpose is to establish a structured and analyzed set of system requirements consistent with the stakeholder requirements.
Process outcomes
1) System requirements are specified. 2) System requirements are structured and prioritized. 3) System requirements are analyzed for correctness and technical feasibility. 4) The impact of system requirements on the operating environment is analyzed. 5) Consistency and bidirectional traceability are established between system requirements and stakeholder requirements. 6) The system requirements are agreed and communicated to all affected parties.

Base Practices
SYS.2.BP1: Specify system requirements. Use the stakeholder requirements to identify and document the functional and non-functional requirements for the system according to defined characteristics for requirements. *Note 1: Characteristics of requirements are defined in standards such as ISO IEEE 29148, ISO 26262-8:2018, or the INCOSE Guide For Writing Requirements.* *Note 2: Examples for defined characteristics of requirements shared by technical standards are verifiability (i.e., verification criteria being inherent in the requirements text), unambiguity/comprehensibility, freedom from design and implementation, and not contradicting any other requirement).*
SYS.2.BP2: Structure system requirements. Structure and prioritize the system requirements. *Note 3: Examples for structuring criteria can be grouping (e.g., by functionality) or product variants identification.* *Note 4: Prioritization can be done according to project or stakeholder needs via e.g., definition of release scopes. Please refer to SPL.2.BP1.*
SYS.2.BP3: Analyze system requirements. Analyze the specified system requirements including their interdependencies to ensure correctness, technical feasibility, and to support project management regarding project estimates. *Note 5: See MAN.3.BP3 for project feasibility and MAN.3.BP5 for project estimates.* *Note 6: Technical feasibility can be evaluated based on e.g., platform or product line, or by means of prototype development or product demonstrators.*

SYS.2.BP4: Analyze the impact on the system context. Analyze the impact that the system requirements will have on elements in the relevant system context.

SYS.2.BP5: Ensure consistency and establish bidirectional traceability. Ensure consistency and establish bidirectional traceability between system requirements and stakeholder requirements.

Note 7: Bidirectional traceability supports consistency, facilitates impact analyses of change requests, and supports the demonstration of coverage of stakeholder requirements. Traceability alone, e.g., the existence of links, does not necessarily mean that the information is consistent with each other.

Note 8: There may be non-functional stakeholder requirements that the system requirements do not trace to. Examples are process requirements. Such stakeholder requirements are still subject to verification.

SYS.2.BP6: Communicate agreed system requirements and impact on the system context. Communicate the agreed system requirements, and results of the impact analysis on the system context, to all affected parties.

SYS.2 System Requirements Analysis	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6
Output Information Items						
17-00 Requirement	X	X				
17-54 Requirement Attribute		X	X			
15-51 Analysis Results			X	X		
13-51 Consistency Evidence					X	
13-52 Communication Evidence						X
Base Practices						
BP1: Specify system requirements	X					
BP2: Structure system requirements		X				
BP3: Analyze system requirements			X			
BP4: Analyze the impact on the system context				X		
BP5: Ensure consistency and establish bidirectional traceability					X	
BP6: Communicate agreed system requirements and impact on the system context						X

4.3.3. SYS.3 System Architectural Design

Process ID
SYS.3
Process name
System Architectural Design
Process purpose
The purpose is to establish an analyzed system architecture, comprising static and dynamic aspects, consistent with the system requirements.
Process outcomes
1) A system architecture is designed including a definition of the system elements with their behavior, their interfaces, their relationships, and their interactions. 2) The system architecture is analyzed against defined criteria, and special characteristics are identified. 3) Consistency and bidirectional traceability are established between system architecture and system requirements. 4) The agreed system architecture and the special characteristics are communicated to all affected parties.

Base Practices
SYS.3.BP1: Specify static aspects of the system architecture. Specify and document the static aspects of the system architecture with respect to the functional and non-functional system requirements, including external interfaces and a defined set of system elements with their interfaces and relationships.
SYS.3.BP2: Specify dynamic aspects of the system architecture. Specify and document the dynamic aspects of the system architecture with respect to the functional and non-functional system requirements including the behavior of the system elements and their interaction in different system modes. *Note 1: Examples of interactions of system elements are timing diagrams reflecting inertia of mechanical components, processing times of ECUs, and signal propagation times of bus systems.*

SYS.3.BP3: Analyze system architecture. Analyze the system architecture regarding relevant technical design aspects related to the product lifecycle, and to support project management regarding project estimates, and derive special characteristics for non-software system elements. Document a rationale for the system architectural design decisions. *Note 2: See MAN.3.BP3 for project feasibility and MAN.3.BP5 for project estimates.* *Note 3: Examples for product lifecycle phases are production, maintenance & repair, decommissioning.* *Note 4: Examples for technical aspects are manufacturability for production, suitability of pre-existing system elements to be reused, or availability of system elements.* *Note 5: Examples for methods being suitable for analyzing technical aspects are prototypes, simulations, and qualitative analyses (e.g., FMEA approaches)* *Note 6: Examples of design rationales are proven-in-use, reuse of a product platform or product line), a make-or-buy decision, or found in an evolutionary way (e.g., set-based design).*
SYS.3.BP4: Ensure consistency and establish bidirectional traceability. Ensure consistency and establish bidirectional traceability between the elements of the system architecture and the system requirements that represent properties or characteristics of the physical end product. *Note 7: Bidirectional traceability further supports consistency, and facilitates impact analysis of change requests, and demonstration of verification coverage. Traceability alone, e.g., the existence of links, does not necessarily mean that the information is consistent with each other.* *Note 8: There may be non-functional requirements that the system architectural design does not trace to. Examples are do not address, or represent, direct properties or characteristics of the physical end product. Such requirements are still subject to verification.*
SYS.3.BP5: Communicate agreed system architecture. Communicate the agreed system architecture, including the special characteristics, to all affected parties.

SYS.3 System Architectural Design	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Output Information Items				
04-06 System Architecture	X			
13-51 Consistency Evidence			X	
13-52 Communication Evidence				X
15-51 Analysis Results		X		
17-57 Special Characteristics		X		
Base Practices				
BP1: Specify static aspects of system architecture	X			
BP2: Specify dynamic aspects of system architecture	X			
BP3: Analyze the system architecture		X		
BP4: Ensure consistency and establish bidirectional traceability			X	

BP5: Communicate agreed system architecture				X

4.3.4. SYS.4 System Integration and Integration Verification

Process ID
SYS.4
Process name
System Integration and Integration Verification
Process purpose
The purpose is to integrate systems elements and verify that the integrated system elements are consistent with the system architecture.
Process outcomes
1) Verification measures are specified for system integration verification of the integrated system elements based on the system architecture, including the interfaces of, and interactions between, system elements. 2) System elements are integrated up to a complete integrated system consistent with the release scope. 3) Verification measures are selected according to the release scope considering criteria, including criteria for regression verification. 4) Integrated system elements are verified using the selected verification measures, and the results of the system integration verification are recorded. 5) Consistency and bidirectional traceability are established between verification measures and the elements of the system architecture. 6) Bidirectional traceability between verification results and verification measures is established. 7) Results of the system integration and integration verification are summarized and communicated to all affected parties.

Base Practices
SYS.4.BP1: Specify verification measures for system integration. Specify the verification measures, based on a defined sequence and preconditions for the integration of system elements against the system static and dynamic aspects of the system architecture, including • techniques for the verification measures, • pass/fail criteria for verification measures, • a definition of entry and exit criteria for the verification measures, and • the required verification infrastructure and environment setup. *Note 1: Examples on what a verification measure may focus are the timing dependencies of the correct signal flow between interfacing system elements, or interactions between hardware and software, as specified in the system architecture. The system integration test cases may focus on* • *the correct signal flow between system items,* • *the timeliness and timing dependencies of signal flow between system items,* • *the correct interpretation of signals by all system items using an interface, and/or* • *the dynamic interaction between system items.*
SYS.4.BP2: Select verification measures. Document the selection of verification measures for each integration step considering selection criteria including criteria for regression verification. The documented selection of verification measures shall have sufficient coverage according to the release scope. *Note 2: Examples for selection criteria can be prioritization of requirements, the need for regression verification (due to e.g., changes to the system architectural design or to system components), or the intended use of the delivered product release (e.g., test bench, test track, public road etc.)*
SYS.4.BP3: Integrate system elements and perform integration verification. Integrate the system elements until the system is fully integrated according to the specified interfaces and interactions between the system elements, and according to the defined sequence and defined preconditions. Perform the selected system integration verification measures. Record the verification measure data including pass/fail status and corresponding verification measure data. *Note 3: Examples for preconditions for starting system integration can be successful system element verification or qualification of pre-existing system elements.* *Note 4: See SUP.9 for handling verification results that deviate from expected results*
SYS.4.BP4: Ensure consistency and establish bidirectional traceability. Ensure consistency and establish bidirectional traceability between verification measures and the system architecture. Establish bidirectional traceability between verification results and verification measures. *Note 5: Bidirectional traceability supports consistency, and facilitates impact analysis of change requests, and demonstration of verification coverage. Traceability alone, e.g., the existence of links, does not necessarily mean that the information is consistent with each other.*

SYS.4.BP5: Summarize and communicate results. Summarize the system integration and integration verification results and communicate them to all affected parties.

Note 6: Providing all necessary information from the test case execution in a summary enables other parties to judge the consequences.

SYS.4 System Integration and Integration Verification	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7
Output Information Items							
08-60 Verification Measure	X						
06-50 Integration Sequence Instruction		X					
03-50 Verification Measure Data				X			
08-58 Verification Measure Selection Set			X				
15-52 Verification Results				X			
13-51 Consistency Evidence					X	X	
13-52 Communication Evidence							X
11-06 Integrated System		X					
Base Practices							
BP1: Specify verification measures for system integration	X						
BP2: Select verification measures			X				
BP3: Integrate system elements and perform integration verification.		X		X			
BP4: Ensure consistency and establish bidirectional traceability					X	X	
BP5: Summarize and communicate results							X

4.3.5. SYS.5 System Verification

Process ID
SYS.5
Process name
System Verification
Process purpose
The purpose is to ensure that the system is verified to be consistent with the system requirements.
Process outcomes
1) Verification measures are specified for system verification of the system based on the system requirements. 2) Verification measures are selected according to the release scope considering criteria, including criteria for regression verification. 3) The integrated system is verified using the selected verification measures and the results of system verification are recorded. 4) Consistency and bidirectional traceability are established between verification measures and system requirements. 5) Bidirectional traceability is established between verification results and verification measures. 6) Verification results are summarized and communicated to all affected parties.

Base Practices

SYS.5.BP1: Specify verification measures for system verification. Specify the verification measures for system verification suitable to provide evidence for compliance with the functional and non-functional information in the system requirements, including

- techniques for the verification measures,
- pass/fail criteria for verification measures,
- a definition of entry and exit criteria for the verification measures,
- necessary sequence of verification measures, and
- the required verification infrastructure and environment setup.

Note 1: The system verification measures may cover aspects such as thermal, environmental, robustness/lifetime, and EMC.

SYS.5.BP2: Select verification measures. Document the selection of verification measures considering selection criteria including criteria for regression verification. The selection of verification measures shall have sufficient coverage according to the release scope.

Note 2: Examples for criteria for selection can be prioritization of requirements, the need for regression verification (due to e.g., changes to the system requirements), the intended use of the delivered product release (test bench, test track, public road etc.)

SYS.5.BP3: Perform verification of the integrated system. Perform the verification of the integrated system using the selected verification measures. Record the verification results including pass/fail status and corresponding verification measure data.

Note 3: See SUP.9 for handling verification results that deviate from expected results

SYS.5.BP4: Ensure consistency and establish bidirectional traceability. Ensure consistency and establish bidirectional traceability between verification measures and system requirements. Establish bidirectional traceability between verification results and verification measures.

Note 4: Bidirectional traceability supports consistency, and facilitates impact analysis of change requests, and demonstration of verification coverage. Traceability alone, e.g., the existence of links, does not necessarily mean that the information is consistent with each other.

SYS.5.BP5: Summarize and communicate results. Summarize the system verification results and communicate them to all affected parties.

Note 5: Providing all necessary information from the test case execution in a summary enables other parties to judge the consequences.

SYS.5 System Verification	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6
Output Information Item						
08-60 Verification Measure	X					
03-50 Verification Measure Data			X			
08-58 Verification Measure Selection Set		X				
15-52 Verification Results			X			
13-51 Consistency Evidence				X	X	
13-52 Communication Evidence						X
Base Practices						
BP1: Specify verification measures for system verification	X					
BP2: Select verification measures		X				
BP3: Perform verification of the integrated system			X			
BP4: Ensure consistency and establish bidirectional traceability.				X	X	
BP5: Summarize and communicate results						X

5. Process capability levels and process attributes

The definition of process capability indicators for each process attribute is an integral part of a measurement framework. Process capability indicators such as generic practices and information items are the means to support the judgment of the degree of achievement of the associated process attribute.

This chapter defines the generic practices and information items and their mapping to the process attributes for each capability level defined in the measurement framework [3.2].

Note: Due to lack of a defined process attribute for process capability level 0, no generic practices and information items are defined.

Process capability level	**Process attribute ID** **Process attribute name** **Process attribute scope** **Process achievements**	Each process attribute is identified with a unique identifier and name. A process attribute scope statement is provided, and process achievements are defined.
Process attribute acievement indicators	**Generic practices**	A set of generic practices for the process attribute providing a definition of the activities to be performed to accomplish the process attribute scope and fulfill the process achievements. The generic practice headers are summarized at the end of a process to demonstrate their relationship to the process attribute achievements.
	Output information items	The output information items that are relevant to accomplish the process attribute scope and fulfill the process achievements are summarized at the end of a process attribute section to demonstrate their relationship to the process achievements. *Note: Refer to Annex B for the characteristics of each information item.*

Table 22 — Template for the process description

5.1. Process capability level 0: Incomplete process

The process is not implemented or fails to achieve its process purpose. At this level there is little or no evidence of any systematic achievement of the process purpose.

5.2. Process capability Level 1: Performed process

The implemented process achieves its process purpose. The following process attribute demonstrates the achievement of this level.

5.2.1. PA 1.1 Process performance process attribute

Process attribute ID
PA 1.1
Process attribute name
Process performance process attribute
Process attribute scope
The process performance process attribute is a measure of the extent to which the process purpose is achieved.
Process attribute achievements
1) The process achieves its defined outcomes.

Generic practices
GP 1.1.1 Achieve the process outcomes Achieve the intent of the base practices. Produce work products that evidence the process outcomes.

PA 1.1 **Process performance process attribute**	Achievement a
Output Information Items	
Process specific information items, as described in chapter 4	X
Generic practices	
GP 1.1.1 Achieve the process outcomes	X

5.3. Process capability Level 2: Managed process

The following process attributes, together with the previously defined process attribute, demonstrate the achievement of this level.

5.3.1. PA 2.1 Process performance management process attribute

Process attribute ID
PA 2.1
Process attribute name
Process performance management process attribute
Process attribute scope
The performance management process attribute is a measure of the extent to which the performance of the process is managed.
Process attribute achievements
1) Strategy for the performance of the process is defined based on identified objectives. 2) Performance of the process is planned. 3) Performance of the process is monitored and adjusted to meet the planning. 4) Needs for human resources including responsibilities and authorities for performing the process are determined. 5) Needs for physical and material resources are determined. 6) Persons performing the process are prepared for executing their responsibilities. 7) Physical and material resources for performing the process are identified, made available, allocated and used. 8) Interfaces between the involved parties are managed to ensure both effective communication and the assignment of responsibilities.

Generic practices
GP 2.1.1: Identify the objectives and define a strategy for the performance of the process. The scope of the process activities including the management of process performance and the management of work products are determined. Corresponding results to be achieved are determined. Process performance objectives and associated criteria are identified. *Note 1: Budget targets and delivery dates to the customer, targets for test coverage and process lead time are examples for process performance objectives.* *Note 2: Performance objectives are the basis for planning and monitoring.* Assumptions and constraints are considered when identifying the performance objectives. Approach and methodology for the process performance is determined. *Note 3: A process performance strategy may not necessarily be document-ed specifically for each process. Elements applicable for multiple processes may be documented jointly, e.g, as part of a common project handbook or in a joint test strategy.*

GP 2.1.2: Plan the performance of the process.

The planning for the performance of the process is established according to the defined objectives, criteria, and strategy.

Process activities and work packages are defined.

Estimates for work packages are identified using appropriate methods.

Note 4: Schedule and milestones are defined.

GP 2.1.3: Determine resource needs.

The required amount of human resources, and experience, knowledge and skill needs for the for process performance are determined based on the planning.

The needs for physical and material resources are determined based on the planning.

Note 5: Physical and material resources may include equipment, laboratories, materials, tools, licenses etc.

Required responsibilities and authorities to perform the process, and to manage the corresponding work products are determined.

Note 6: The definition of responsibilities and authorities does not necessarily require formal role descriptions.

GP 2.1.4: Identify and make available resources.

The individuals performing and managing the process are identified and allocated according to the determined needs.

The individuals performing and managing the process are being qualified to execute their responsibilities.

Note 7: Qualification of individuals may include training, mentoring, or coaching.

The other resources, necessary for performing the process are identified, made available, allocated and used according to the determined needs.

GP 2.1.5: Monitor and adjust the performance of the process.

Process performance is monitored to identify deviations from the planning.

Appropriate actions in case of deviations from the planning are taken.

The planning is adjusted as necessary.

GP 2.1.6: Manage the interfaces between involved parties.

The individuals and groups including required external parties involved in the process performance are determined.

Responsibilities are assigned to the relevant individuals or parties.

Communication mechanisms between the involved parties are determined.

Effective communication between the involved parties is established and maintained.

PA 2.1 Process Performance Management	Achievement 1	Achievement 2	Achievement 3	Achievement 4	Achievement 5	Achievement 6	Achievement 7	Achievement 8
Output Information Items								
19-01 Process performance strategy	X							
18-58 Process performance objectives	X							
14-10 Work package		X						
08-56 Schedule		X	X					
13-14 Progress status			X					
17-55 Resource needs				X	X			
08-61 Resource allocation						X	X	
08-62 Communication matrix								X
13-52 Communication evidence								X
Generic Practices								
GP 2.1.1: Identify the objectives and define a strategy for the performance of the process	X							
GP 2.1.2: Plan the performance of the process		X						
GP 2.1.3: Determine resource needs				X	X			
GP 2.1.4: Identify and make available resources						X	X	
GP 2.1.5: Monitor and adjust the performance of the process			X					
GP 2.1.6: Manage the interfaces between involved parties								X

5.3.2. PA 2.2 Work product management process attribute

Process attribute ID
PA 2.2
Process attribute name
Work product management process attribute
Process attribute scope
The work product management process attribute is a measure of the extent to which the work products produced by the process are appropriately managed.
Process attribute achievements
1) Requirements for the work products of the process are defined. 2) Requirements for storage and control of the work products are defined. 3) The work products are appropriately identified, stored, and controlled. 4) The work products are reviewed and adjusted as necessary to meet requirements.

Generic practices
GP 2.2.1 Define the requirements for the work products. The requirements for the content and structure of the work products to be produced are defined. Quality criteria for the work products are identified. Appropriate review and approval criteria for the work products are defined. *Note 1: Possible sources of documentation requirements may be e.g., best practices or lessons learned from other projects, standards, organization requirements, customer requirements, etc.* *Note 2: There may be types of work products for which no review or approval is required, thus then there would be no need to define the corresponding criteria.*
GP 2.2.2 Define the requirements for storage and control of the work products. Requirements for the storage and control of the work products are defined, including their identification and distribution. *Note 3: Possible sources for the identification of requirements for storage and control may be e.g., legal requirements, data policies, best practices from other projects, tool related requirements, etc.* *Note 4: Examples for work product storage are files in a file system, ticket in a tool, Wiki entry, paper documents etc.* *Note 5: Where status of a work product is required in base practices, this should be managed via a defined status model.*

GP 2.2.3 Identify, store and control the work products. The work products to be controlled are identified. The work products are stored and controlled in accordance with the requirements. Change control is established for work products. Versioning and baselining of the work products is performed in accordance with the requirements for storage and control of the work products. The work products including the revision status are made available through appropriate mechanisms.
GP 2.2.4 Review and adjust work products. The work products are reviewed against the defined requirements and criteria. Resolution of issues arising from work products reviews is ensured.

PA 2.2 Work product management process attribute	Achievement 1	Achievement 2	Achievement 3	Achievement 4
Output Information Items				
17-05 Requirements for work products	X	X		
18-59 Review and approval criteria for work products	X			
18-07 Quality criteria	X			
13-19 Review evidence				X
13-08 Baseline			X	
16-00 Repository			X	
Generic Practices				
GP 2.2.1 Define the requirements for the work products	X			
GP 2.2.2 Define the requirements for storage and control of the work products		X		
GP 2.2.3 Identify, store and control the work products			X	
GP 2.2.4 Review and adjust work products.				X

5.4. Process capability Level 3: Established process

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level.

5.4.1. PA 3.1 Process definition process attribute

Process attribute ID
PA 3.1
Process attribute name
Process definition process attribute
Process attribute scope
The process definition process attribute is a measure of the extent to which a standard process is maintained to support the deployment of the defined process.
Process attribute achievements
1) A standard process is developed, established, and maintained that describes the fundamental elements that must be incorporated into a defined process. 2) The required inputs and the expected outputs for the standard process are defined. 3) Roles, responsibilities, authorities, and required competencies for performing the standard process are defined. 4) Tailoring guidelines for deriving the defined process from the standard process are defined. 5) Required physical and material resources and process infrastructure needs are determined as part of the standard process. 6) Suitable methods and required activities for monitoring the effectiveness, suitability and adequacy of the process are determined.

Generic practices
GP 3.1.1 Establish and maintain the standard process. A suitable standard process is developed including required activities and their interactions. Inputs and outputs of the standard process are defined including the corresponding entry and exit criteria to determine the interactions and sequence with other processes. Process performance roles are identified and assigned to the standard process activities including their type of involvement, responsibilities, and authorities. *Note 1: An example for describing the involvement of the process roles in the activities is a RASI/RASIC representation.* Suitable guidance, procedures, and templates are provided to support the execution of the process as needed. *Note 2: Procedures may also include description of specific methods to be used.* Appropriate tailoring guidelines including predefined unambiguous criteria as well as predefined and unambiguous proceedings are defined based on identified deployment needs and context of the standard process. The standard process is maintained according to corresponding feedback from the monitoring of the deployed processes. *Note 3: For guidance on how to perform process improvements see the Process Improvement process (PIM.3).*

GP 3.1.2 Determine the required competencies. Required competencies, skills, and experience for performing the standard process are determined for the identified roles. Appropriate qualification methods to acquire the necessary competencies and skills are determined, maintained, and made available for the identified roles. *Note 4: Qualification methods are e.g., trainings, mentoring, self-study.* *Note 5: Preparation includes e.g., identification or definition of trainings, mentoring concepts, self-learning material.*
GP 3.1.3 Determine the required resources. Required physical and material resources and process infrastructure needs for performing the standard process are determined. *Note 6: This may include e.g., facilities, tools, licenses, networks, services, and samples supporting the establishment of the required work environment.*
GP 3.1.4 Determine suitable methods to monitor the standard process. Methods and required activities for monitoring the effectiveness and adequacy of the standard process are determined. *Note 7: Methods and activities to gather feedback regarding the standard process may be lessons learned, process compliance checks, internal audits, management reviews, change requests, reflection of state-of-the-art such as applicable international standards, etc.* Appropriate criteria and information needed to monitor the standard process are defined. *Note 8: Information about process performance may be of qualitative or quantitative nature.*

PA 3.1 Process definition process attribute	Achievement 1	Achievement 2	Achievement 3	Achievement 4	Achievement 5	Achievement 6
Output Information Items						
06-51 Tailoring guideline				X		
08-63 Process monitoring method						X
10-00 Process description	X	X				
10-50 Role description			X			
10-51 Qualification method description			X			
10-52 Process resource and infrastructure description					X	
Generic Practices						
GP 3.1.1 Establish and maintain the standard process	X	X	X	X		
GP 3.1.2 Determine the required competencies			X			
GP 3.1.3 Determine the required resources					X	

GP 3.1.4 Determine suitable methods to monitor the standard process						X

5.4.2. PA 3.2 Process deployment process attribute

Process attribute ID
PA 3.2
Process attribute name
Process deployment process attribute
Process attribute scope
The process deployment process attribute is a measure of the extent to which the standard process is deployed as a defined process to achieve its process outcomes.
Process attribute achievements
1) A defined process is deployed based upon an appropriately selected and/or tailored standard process. 2) Assignment of persons necessary for performing the defined process to roles is performed and communicated. 3) Required education, training and experience is ensured and monitored for the person(s) assigned to the roles. 4) Required resources for performing the defined process are made available, allocated, and maintained. 5) Appropriate information is collected and analyzed as a basis for understanding the behavior of the process.

Generic practices
GP 3.2.1 Deploy a defined process that satisfies the context specific requirements of the use of the standard process. The defined process is appropriately selected and/or tailored from the standard process. Conformance of defined process with standard process requirements and tailoring criteria is verified. The defined process is used as managed process to achieve the process outcomes. *Note 1: Changes in the standard process may require updates of the defined process.*
GP 3.2.2 Ensure required competencies for the defined roles. Human resources are allocated to the defined roles according to the required competencies and skills. Assignment of persons to roles and corresponding responsibilities and authorities for performing the defined process are communicated. Gaps in competencies and skills are identified, and corresponding qualification measures are initiated and monitored.

Availability and usage of the project staff are measured and monitored.
GP 3.2.3 Ensure required resources to support the performance of the defined process. Required information to perform the defined process is made available, allocated and used. Required physical and material resources, process infrastructure and work environment are made available, allocated and used. Availability and usage of resources are measured and monitored.
GP 3.2.4 Monitor the performance of the defined process. Information is collected and analyzed according to the determined process monitoring methods to understand the effectiveness and adequacy of the defined process. Results of the analysis are made available to all effected parties and used to identify where continual improvement of the standard and/or defined process can be made. *Note 2: For guidance on how to perform process improvements see the Process Improvement process (PIM.3).*

PA 3.2 Process deployment process attribute	Achievement 1	Achievement 2	Achievement 3	Achievement 4	Achievement 5
Output Information Items					
10-00 Process description	X				
15-54 Tailoring documentation	X				
14-53 Role assignment		X	X		
13-55 Process resource and infrastructure documentation				X	
03-06 Process performance information					X
Generic Practices					
GP 3.2.1 Deploy a defined process	X				
GP 3.2.2 Ensure required competencies		X	X		
GP 3.2.3 Ensure required resources				X	
GP 3.2.4 Monitor the performance of the defined process					X

5.5. Process capability Level 4: Predictable process

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level.

5.5.1. PA 4.1 Quantitative analysis process attribute

Process attribute ID
PA 4.1
Process attribute name
Quantitative analysis process attribute
Process attribute scope
The quantitative analysis process attribute is a measure of the extent to which information needs are defined, relationships between process elements are identified and data are collected.
Process attribute achievements
1) Process information needs in support of relevant defined quantitative business goals are established. 2) Measurable relationships between process elements that contribute to the process performance, and data collection techniques and data collection frequency, are identified. 3) Process measurement objectives are derived from process information needs. 4) Techniques for analyzing the collected data are selected. 5) Quantitative control limits for process performance in support of relevant business goals are established. 6) Results of measurement are collected, validated and reported in order to monitor the extent to which the quantitative targets/objectives for process performance are met. *Note: Information needs typically reflect management, technical, project, process or product needs.*

Generic practices
GP 4.1.1 Identify business goals. Business goals are identified that are supported by the quantitatively measured process.
GP 4.1.2 Establish process information needs. Stakeholders of the identified business goals and the quantitatively measured process are identified, and their information needs are defined and agreed.
GP 4.1.3 Identify measurable relationships between process elements. Identify the relationships between process elements, or sets of process elements, which contribute to the process information needs. *Note 1: Examples of process elements are work products, activities, tasks.*

GP 4.1.4 Derive process measurement approach and select analysis techniques. Based on the measurable relationships of process elements, or set of process elements, the process measurement metrics are derived to satisfy the established process information needs. Frequency of data collection is defined. Select analysis techniques, appropriate to collected data. Algorithms and methods to create derived measurement results from base measures are defined, as appropriate. Verification mechanism for base and derived measures is defined. *Note 2: Typically, the standard process definition is extended to include the collection of data for process measurement.*
GP 4.1.5 Establish quantitative control limits. Establish quantitative control limits for the derived metrics. Agreement with process stakeholders is established.
GP 4.1.6 Collect product and process measurement results through performing the defined process. Data collection mechanisms are created for all identified metrics. Required data is collected across process instances of within the defined frequency and recorded. Measurement results are analyzed and reported to the identified stakeholders. *Note 3: A product measure can contribute to a process measure, e.g., the productivity of testing characterized by the number of defects found in a given timeframe in relation to the product defect rate in the field.*

PA 4.1 Quantitative analysis process attribute	Achievement 1	Achievement 2	Achievement 3	Achievement 4	Achievement 5	Achievement 6
Output Information Items						
18-70 Business goals	X	X				
07-61 Quantitative process metric		X	X			
07-62 Process analysis techniques				X		
07-63 Process control limits					X	
07-64 Process measurement data						X
Generic Practices						
GP 4.1.1 Identify business goals	X					
GP 4.1.2 Establish process information needs	X					

GP 4.1.3 Identify measurable relationships between process elements		X				
GP 4.1.4 Derive process measurement approach and select analysis techniques			X	X		
GP 4.1.5 Establish quantitative control limits					X	
GP 4.1.6 Collect product and process measurement results through performing the de-fined process						X

5.5.2. PA 4.2 Quantitative control process attribute

Process attribute ID
PA 4.2
Process attribute name
Quantitative control process attribute
Process attribute scope
The quantitative control process attribute is a measure of the extent to which objective data are used to manage process performance that is predictable.
Process attribute achievements
1) Variations in process performance are identified. 2) Assignable causes of process variation are determined through analysis of the collected quantitative data. 3) Distributions that characterize the performance of the process are established. 4) Corrective actions are taken to address assignable causes of variation.

Generic practices
GP 4.2.1 Identify variations in process performance. Deviations in the performance of process instances from the established quantitative control limits are determined based on the collected quantitative measurement data.
GP 4.2.2 Identify causes of variation. The determined deviations in process performance are analyzed to identify potential cause(s) of variation using the defined analysis techniques. Distributions are used to quantitatively understand the variation of process performance under the influence of potential causes of variation. Consequences of process variation are analyzed.

GP 4.2.3 Identify and implement corrective actions to address assignable causes.

Results are provided to those responsible for taking action.

Corrective actions are determined and implemented to address each assignable cause of variation.

Corrective action results are monitored and evaluated to determine their effectiveness.

Note 1: Assignable cause may indicate a possible problem in the defined process.

PA 4.2 Quantitative control process attribute	Achievement 1	Achievement 2	Achievement 3	Achievement 4
Output Information Items				
15-57 Quantitative process analysis results	X	X	X	
08-66 Measures against deviations in quantitative process analysis				X
Generic Practices				
GP 4.2.1 Identify variations in process performance	X			
GP 4.2.2 Identify causes of variation		X	X	
GP 4.2.3 Identify and implement corrective actions to address assignable causes				X

5.6. Process capability Level 5: Innovating process

The following process attributes, together with the previously defined process attributes, demonstrate the achievement of this level.

5.6.1. PA 5.1 Process innovation process attribute

Process attribute ID
PA 5.1
Process attribute name
Process innovation process attribute
Process attribute scope
The process innovation process attribute is a measure of the extent to which changes to the process are identified from investigations of innovative approaches to the definition and deployment of the process.
Process attribute achievements
1) Process innovation objectives are defined that support the relevant business goals. 2) Quantitative data are analyzed to identify opportunities for innovation. 3) Innovation opportunities derived from new technologies and process concepts are identified.

Generic practices
GP 5.1.1 Define the process innovation objectives for the process that support the relevant business goals. New business visions and goals are analyzed to give guidance for new process objectives and potential areas of process innovation. Quantitative and qualitative process innovation objectives are defined and documented.
GP 5.1.2 Analyze quantitative data of the process. Common causes of variation in process performance across process instances are identified and analyzed to get a quantitative understanding of their impact.
GP 5.1.3 Identify innovation opportunities. Identify opportunities for innovation based on the quantitative understanding of the analyzed data. Industry best practices, new technologies and process concepts are identified and evaluated. Feedback on opportunities for innovation is actively sought. Emergent risks are considered in evaluating improvement opportunities.

PA 5.1 Process innovation process attribute	Achievement 1	Achievement 2	Achievement 3
Output Information Items			
18-80 Improvement opportunity	X		X
15-58 Common cause of variation analysis results		X	
Generic Practices			
GP 5.1.1 Define the process innovation objectives for the process that support the relevant business goals	X		
GP 5.1.2 Analyze quantitative data of the process		X	
GP 5.1.3 Identify innovation opportunities			X

5.6.2. PA 5.2 Process innovation implementation process attribute

Process attribute ID
PA 5.2
Process attribute name
Process innovation implementation process attribute
Process attribute scope
The process innovation process implementation attribute is a measure of the extent to which changes to the definition, management and performance of the process achieves the relevant process innovation objectives.
Process attribute achievements
1) Impact of all proposed changes is assessed against the objectives of the defined process and standard process. 2) Implementation of all agreed changes is managed to ensure that any disruption to the process performance is understood and acted upon. 3) Effectiveness of process change on the basis of quantitative performance and innovation feedback is evaluated.

Generic practices
GP 5.2.1 Define and assess the impact of proposed changes. Specified changes are assessed against product quality and process performance requirements and goals. Impact of changes to other defined and standard processes is considered. Objective priorities for process innovation are established. Commitment to innovation is demonstrated by organizational management including other relevant stakeholders.
GP 5.2.2 Implement agreed process changes. A mechanism is established for incorporating accepted changes into the defined and standard process(es) effectively and completely. Process changes are implemented and effectively communicated to all affected parties.

GP 5.2.3 Evaluate the effectiveness of process change.

Performance and capability of the changed process are measured and compared with historical data.

Performance and capability of the changed process are analyzed to determine whether the process performance has improved with respect to common causes of variations.

Other feedback is recorded, such as opportunities for further innovation of the standard process.

A mechanism is available for documenting and reporting analysis results to stakeholders of standard and defined process.

PA 5.2 Process innovation implementation attribute	Achievement a	Achievement b	Achievement c
Output Information Items			
18-81 Improvement evaluation results	X		X
08-66 Measures against deviations in quantitative process analysis		X	X
Generic Practices			
GP 5.2.1 Define and assess the impact of proposed changes	X		
GP 5.2.2 Implement agreed process changes		X	
GP 5.2.3 Evaluate the effectiveness of process change			X